Secular Trends in Physical Fitness of Mozambican School-Aged Children and Adolescents

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Objective: This study presents information about secular trends in physical fitness (PF) levels among Mozambican youth.

Methods: The sample comprises 3,851 subjects (1,791 boys; 2,060 girls) aged 8–15 years who were evaluated at three time points (1992, 1999, 2012). PF tests included handgrip strength, 10 m × 5 m shuttle-run, sit-and-reach, and 1-mile run/walk. Biological maturity was assessed by sexual characteristics, and percentage body fat was predicted using triceps and subscapular skinfolds. ANCOVA (controlling for age, maturity status, and percentage body fat) was used to compare mean differences in PF tests among the three time points, by sex.

Results: Children in 1992 were more flexible than those from 2012; boys handgrip strength increased from 1992 to 2012, while girls decreased their handgrip strength; youth in 1992 were faster and more agile than their 2012 peers; and a decrease was observed in cardiorespiratory fitness between 1992 and 1999 and between 1992 and 2012 for both sexes.

Conclusions: A negative secular trend among Mozambican children’s PF was observed over the last two decades, suggesting that socio-political, educational, and economical changes occurring during this period had a relevant effect on their PF. This negative trend suggests that development of intervention programs/strategies to improve PF among youth is warranted. Am. J. Hum. Biol. 00:000–000, 2014. © 2014 Wiley Periodicals, Inc.
purpose of this investigation was to study secular changes in PF levels among Mozambican school children and adolescents, aged 8–15 years, in 1992, 1999, and 2012, i.e., from the end of the War until a period of peace and economic growth.

METHODS

Mozambique

Mozambique is a country located in Southeast Africa, bordered by the Indian Ocean, Tanzania, Malawi, Zambia, Zimbabwe, Swaziland, and South Africa, with an estimated total population (in 2012) of approximately 25 million (World Health Organization, 2013a), and a population growth rate of 2.4% (UNICEF, 2013). During the last two decades, Mozambique has experienced economical and social changes that improved several markers of quality of life. For example, from the early 1990s to 2010s the Mozambican Gross Domestic Product per capita increased from $86.9 (Ministério do Plano e Finanças, 1998) to approximately $510 (The World Bank, 2013); life expectancy, that was around 43 years twenty years ago (World Health Organization, 2013b), was 53 years in 2011 (World Health Organization, 2013b); child mortality (children under five) declined from 226 per 1000 live births (World Health Organization, 2013b) to 103 deaths per 1000 live births (World Health Organization, 2013b); adult literacy increased from about 39.5% (UNDP, 2000) to 50.6% (UNICEF, 2013); and about 31% of the population live in urban areas (UNICEF, 2013). On the other hand, the high rate of Mozambican population living in poverty (54.7%) (The Word Bank, 2013), and the Human Development Index of 0.327 (UNDP, 2013), indicate that Mozambique is still a country of low human development.

Sample

The sample of the present study comprises children and adolescents, aged 8–15 years, measured in three time periods: 1992 (just after the end of the War), 1999, and 2012. The sampling recruitment, a three-stage cluster sampling (areas, schools, and students) of this time-lag design has been consistent, as children and adolescents were enlisted from the same schools living in Maputo’s urban or suburban areas (Prista et al., 2002a). The sample is part of the “Human Biological Variability—Implications for Physical Education, Sports, Preventive Medicine and Public Health” research project (Prista et al., 2010), which describes the patterns of human variability in growth, biological maturation, and development of Mozambican youth, in order to understand the role of genetic and environmental factors in the variability of these indicators in this population.

All children provided a written consent form, signed by parents or legal guardians, authorizing their participation in the study. Children with chronic diseases, physical handicaps, or psychological disorders were excluded during the sample selection. Those younger than 8 years or older than 15 years were excluded during data screening because the number of subjects was very small. Subjects with missing information (missing at random) in all variables were included during data analysis, as no significant differences were identified among children/adolescents with missing information and those with complete information. As such, the total sample comprises 3,851 subjects (1,791 boys, 2,060 girls; see Table 1), and is distributed as follows: 591 subjects in 1992 (276 boys, 315 girls); 1,840 subjects in 1999 (854 boys, 986 girls), and 1,420 subjects in 2012 (661 boys, 759 girls). The study protocol was approved by the Mozambican National Bioethics Committee.

Body composition

In the three data collection periods, triceps and subscapular skinfolds were measured according to the work by Lohman et al. (1988), and a GPM (Siber-Hegner, Switzerland) skinfold caliper (±0.2 mm) was used. All measurements were made by the same trained personnel in order to minimize measurement errors and guarantee privacy—girls were measured by female technicians, and boys were measured by male technicians. The Boileau et al. (1985) formula was used to estimate percent body fat (%BF).

Physical Fitness

PF was assessed with four tests. Two tests are part of the EUROFIT battery (EUROFIT, 1988) used to measure static strength (handgrip strength) and speed/agility (10 m × 5 m shuttle run); flexibility and cardiorespiratory fitness were evaluated, respectively, with the sit-and-reach and the 1-mile run/walk tests from the AAHPERD (AAHPERD, 1980) and FITNESSGRAM (Cooper Institute for Aerobics Research, 1987) batteries, respectively. The same methods and procedures were used in the three data collection periods by trained personnel. In 1992, children aged 13–15 did not perform the 1-mile run/walk test but the 2,400 m run; therefore they were removed from the analysis. All tests were performed according to standardized instructions, as follows:

<table>
<thead>
<tr>
<th>Age</th>
<th>B</th>
<th>G</th>
<th>Total</th>
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<tbody>
<tr>
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<td>26</td>
<td>38</td>
<td>64</td>
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<td>10</td>
<td>43</td>
<td>38</td>
<td>81</td>
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<td>11</td>
<td>42</td>
<td>48</td>
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<td>12</td>
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<td>13</td>
<td>42</td>
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<td>19</td>
<td>41</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>29</td>
<td>31</td>
<td>60</td>
</tr>
<tr>
<td>TOTAL</td>
<td>276</td>
<td>315</td>
<td>591</td>
</tr>
</tbody>
</table>
1. **Handgrip strength** was measured (kg) in a standing position using a digital hand dynamometer (Takei TKK 5401, Tokyo, Japan). Subjects squeezed the dynamometer with maximal force, holding it away from the body with the arm extended, using the preferred hand.

2. **Sit-and-reach** trunk flexibility was measured with subjects seated on the floor with legs extended to front. Subjects reached forward, and the maximum distance achieved with the tip of the middle fingers through trunk flexion was measured (cm) using a standardized wooden stand.

3. The **Shuttle-run test** required each subject to perform five cycles (round-trip) at maximum velocity between two lines marked 10 m apart from one another. Time was recorded in seconds.

4. **1-mile run/walk test** required subjects to cover the 1-mile distance in the shortest time possible, running or walking. Time was recorded in seconds.

**Biological maturation**

Children and adolescents were assessed for their biological maturity based on their secondary sexual characteristics (pubic hair stages), according to procedures described by Tanner and Whitehouse (1982). Trained observers from the same sex rated all children/adolescents.

**Statistical analysis**

Basic descriptive statistics were computed. Analysis of covariance (ANCOVA), controlling for age, maturity status, and %BF was used to compare each PF test, by sex, among the three different time periods. Bonferroni adjustments were made in all multiple comparisons. SPSS 20.0 was used in all analysis. The statistical significance level was set at 5%.

**RESULTS**

Figure 1 presents secular trends in PF and %BF across the three time points (1992, 1999, and 2012), by age and sex. Children and adolescents in 2012 had higher %BF than those from 1992. In general, boys and girls in 1992 outperformed those from 2012 in sit-and-reach, shuttle-run, and in the 1-mile run/walk test. However, children and adolescents from 2012 performed better than those from 1992 in the handgrip test.

Table 2 shows the ANCOVA results (means ± standard errors, F and P-values) for each PF test by sex, controlling for age, maturity status, and %BF. Children from the 1992 cohort were more flexible than those from 2012, but in boys no differences were observed between 1999 and 2012. In the handgrip, results were different for boys and girls; while boys became stronger from 1992 to 2012, girls decreased their performance (significant differences among three time points, for both sexes). In the speed/agility test, boys and girls in 1992 were faster and more agile than their 2012 peers, but no statistically significant differences were found between 1992 and 1999 in boys. Finally, for cardiorespiratory fitness, the same pattern was observed for both sexes: a decrease in performance, with statistically significant differences between 1992 and 1999 and 1992 and 2012. Figure 2 shows mean values for each PF test, controlling for age, biological status, and %BF along the three time periods.

**DISCUSSION**

Using information from 1992, 1999, and 2012, this study presented secular changes in PF among 8–15 years old Mozambican youth, comprising a 20-year period of economic growth and improvements in the population’s quality of life. In general, Mozambican children and adolescents of 2012 had lower cardiorespiratory fitness, speed-agility, and flexibility levels than their counterparts of 20 years before; in static strength, boys were stronger in 2012 than those from 1992, while girls were weaker. Taken together these results demonstrated a negative secular trend in PF (except for handgrip strength in boys where the trend is positive), reflecting the influence of lifestyle and environmental changes on youth fitness. In other words, these PF changes may have been affected by physical factors resulting from behavioral changes (such as increasing time in sedentary activities, decreasing engagement in active tasks during leisure time, and replacing walking with motorized transport), which are
driven by socio-economic and demographic shifts (Tomkinson, 2004).

The negative trend in flexibility is similar to what was also found in Estonian and Lithuanian youth—a decrease in performance over time (Jurimae et al., 2007). Although we were not able to find any reference concerning secular trends in flexibility among African children, it is possible that these results can also be found in other African societies. The likely explanation for these results may be related to changes in body size (body height and weight) in Mozambican children and adolescents from 1992 to 2012 (dos Santos et al., unpublished data), which have also been observed in developing countries as a consequence of economic transition (Akachi and Canning, 2007; Malina et al., 2004; Marques-Vidal et al., 2008; World Health Organization, 2000). During this period, a net improvement in the quality of life, health, and sanitation was observed with intensifications in urbanization, sedentary occupations, availability of private transportation, and the advent of fast-food (Prista et al., 2003). Further, increases in youth body size (children and adolescents became taller and heavier than those 20 years before [data not shown]) may have played a part. As is well known, flexibility levels as assessed by the sit-and-reach test are dependent on body proportions (namely leg length, trunk length, and arm length and their respective ratios) (Nevill et al., 2009). As such, positive secular changes in growth patterns observed among Mozambican youth, as a consequence of economic and social changes after the end of the War (dos Santos et al., unpublished observation; Prista et al., 2002b), may explain, in part, the negative trend, where heavier and taller children are less flexible than those smaller and thinner from the past. It is also possible that a reduction in physical activity levels and traditional games/unstructured play (Saranga et al., 2008) may be a putative cause for such a declining pattern.

Static strength trends were different in boys and girls; boys showed a positive secular trend, while girls had a negative trend. In Spanish adolescent boys and girls (Moliner-Urdiales et al., 2010), a decrease in their handgrip strength was observed from 2001–2002 to 2006–2007 (from 36.6 kg to 32.1 kg for boys; and from 27.6 kg to 23.0 kg for girls), with a similar trend among Mozambican girls (a decline from 22.0 kg to 20.4 kg), but different in boys, with an increase in performance from 20.1 kg to 22.5 kg. Other studies have investigated changes in upper body muscular strength but the results were not conclusive—some observed increases (Jurimae et al., 2007), others a decrease (Jurimae et al., 2007) or stability (Moliner-Urdiales et al., 2010) in performance during a variable range of time periods, from 5 to 10 years. It is most likely that the positive trend found in Mozambican boys is related to their increases in body weight. There is some evidence showing that overweight/obese schoolchildren score higher than children of normal weight in tests requiring isometric strength (Deforche et al., 2003). This trend is usually explained by increased fat-free mass to support the extra weight, meaning extra strength (Banthin et al., 1999; Deforche et al., 2003; Forbes, 1964). However, in girls, the absence of a mass component explaining the negative trend requires that we look elsewhere, namely changes in their lifestyle, especially increases in their sedentary activities and reductions in their involvement in daily chores/traditional games (Saranga et al., 2008). Similar results with comparable explanations were previously found in European girls (Tutkuviene and Schiefenhovel, 2013).

Using the same test to measure speed/agility, Flemish girls aged 12–18 years studied from 1979–1980 to 2005

### Table 2. Age-, maturity status-, and %BF-adjusted means ± standard errors for boys and girls physical fitness tests (aged 8–15 years) by time period

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>1999</th>
<th>2012</th>
<th>P</th>
<th>Pairwise comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SR (cm)</td>
<td>236</td>
<td>34.09 ± 0.39</td>
<td>651</td>
<td>32.83 ± 0.23</td>
<td>506</td>
</tr>
<tr>
<td>HG (kg)</td>
<td>240</td>
<td>20.11 ± 0.3</td>
<td>662</td>
<td>20.95 ± 0.18</td>
<td>510</td>
</tr>
<tr>
<td>10×5 (sec)</td>
<td>224</td>
<td>21.88 ± 0.11</td>
<td>636</td>
<td>22.12 ± 0.06</td>
<td>504</td>
</tr>
</tbody>
</table>

| Girls |      |      |      |       |                      |
| SR (cm) | 269  | 38.03 ± 0.37 | 728  | 36.52 ± 0.22 | 590  | 35.41 ± 0.26 | 15.572 | < 0.001 | 1992 > 2012 |
| HG (kg) | 276  | 21.97 ± 0.26 | 765  | 21.03 ± 0.16 | 594  | 20.39 ± 0.19 | 10.755 | < 0.001 | 1992 > 2012 |
| 10×5 (sec) | 253  | 22.49 ± 0.12 | 754  | 22.9 ± 0.07  | 581  | 23.66 ± 0.08 | 37.387 | < 0.001 | 1992 < 2012 |
| 1MR (sec) | 138  | 533.37 ± 9.52 | 439  | 529.84 ± 5.28 | 450  | 730.26 ± 5.44 | 328.870 | < 0.001 | 1992 < 2012 |

SR: Sit and Reach; HG: HandGrip; 10×5: Shuttle-run (10 × 5 meter); 1 MR: 1 mile run. P-values and pairwise comparisons are also presented.
showed a similar trend as Mozambican girls, i.e., increased performance time at all ages, with the highest difference found at 16 years of age (from 21.7 s to 23.3 s), and the lowest difference at 13 years (from 22.9 s to 21.9 s) (Matton et al., 2007). However, among boys, the trend observed in Mozambicans differed from that observed among the Flemish: Mozambicans reduced their speed/agility performance across the years, increasing the time to complete the test (from 21.9 s in 1992 to 22.5 s in 2012), while in Flemish boys a time reduction at all ages was observed (decreases varied from 0.24 s to 0.74 s) (Matton et al., 2007). Further, changes in speed/agility among Mozambican youth, in both sexes, also differed from those found among Estonians and Lithuanians aged 11 to 17 years (studied from 1992 to 2002) (Jurimae et al., 2007), where no statistically significant difference was observed in this fitness component (mean changes ranging from a decline of −0.09% to an improvement of +0.34%, among Lithuanian girls and boys, respectively). Differences among these results could be related to sample characteristics and protocols (e.g., differences in running surfaces or practices runs).

Among Mozambican youth, a marked decline in cardiopulmonary fitness, assessed by the 1-mile run/walk test was observed. Mozambican boys and girls needed, on average, more time to cover the distance. Similarity, using a long distance test to determine secular changes in aerobic fitness, namely a 2,000 m running test for boys and a 1,500 m running test for girls, Huotari et al. (2010a) reported a deterioration in aerobic fitness among Finnish youth (aged 13–18 years old) from 1976 to 2001, with an increase, in average, of 56 s for boys (from 559 s to 615 s) and 29 s for girls (from 494 s to 523 s) over time. Among Hungarian boys, aged 7–14 years, a decrease in aerobic fitness performance, assessed by a 1,200 m running test, was also found, with a decline between 7 and 12% over thirty years (1975–2005) (Photiou et al., 2008); and using a 1,000 m running test, Watanabe et al. (1998) showed a decline in running performance among 12-year-old Japanese girls from 1968 to 1994. Since speed/agility and cardiopulmonary fitness levels are related to body size and composition (Nevill et al., 2009), the decline in these PF components could be linked with increased body size observed among Mozambican youth in the last 20 years (unpublished data). In addition, it is also possible that psychosocial factors could interfere with performance, as fatter children and adolescents usually have lower self-esteem and self-efficacy, making them less motivated to perform PF assessments, namely the 1-mile run/walk (Welk, 1999), although no such data are available in Mozambican youth over the years.

Notwithstanding the relevancy of the present results, several limitations are acknowledged. Firstly, no information about physical activity habits during these 20 years was presented in this report as this could probably facilitate the interpretation. Yet, most of the available research concerning secular trends in PF rarely, if ever, include this issue in their analysis. In some studies no such information was available, while in others it probably was but with time different instruments were used which makes the comparisons and interpretations very difficult. Further, there is also some controversy about the precise magnitude of the association between physical activity and PF levels (Dencker et al., 2006; Kemper and Koppes, 2006). Secondly, the use of field tests to measure speed/agility, flexibility, cardiopulmonary, and muscular fitness result in measurement errors at the individual level, but this is present in all studies across the globe that used similar tests. In order to minimize systematic measurement error, trained technicians used the same methodology during the three time periods. Further, they were trained by the same Mozambican principal investigator according to the same assessment manual and training protocol. Despite these limitations, this study has important positive points. Firstly, it shows an important and consistent data set in an African country during an important transitional period. Secondly, the use of three time points covered relevant economic and social changes in Mozambique. Thirdly, the use of the same tests and measurement protocols at all time points is a marked strength. Fourthly, the relatively large sample sizes for such a country in economic transition, given the costs associated with this type of studies, is also a strength. Finally, the age range covers an important lifetime period—childhood and adolescence.

In conclusion, the present study showed a negative secular trend in Mozambican boys’ and girls’ speed/agility, flexibility, and cardiopulmonary fitness, and a similar trend in girls’ static strength. However, a positive trend in boys’ static strength was found. Furthermore, a systematic positive secular trend was observed in %BF. Taken together these results suggest that political and socioeconomic changes occurring in Mozambique during the last 20 years had a relevant impact on youth’s PF, which are most possibly linked to changes in lifestyle. These results call for public education policies and intervention strategies to improve children’s and adolescents’ PF as it is a putative marker of their health.

LITERATURE CITED


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